

Detection and Analysis of Anomalous Radioxenon Isotopes

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INTRODUCTION

The xenon isotopes of ^{125}Xe , ^{127}Xe , $^{129\text{m}}\text{Xe}$, and ^{122}Xe were observed in Knoxville, TN. Xenon International detected these isotopes periodically from December 2019 until May 2021. Next generation radioxenon systems could see more of these isotopes from research facilities.

METHODS/DATA

Geant4 simulations were performed for several xenon isotopes and their decay chains. These simulations were used to extract coincidence spectra to compare with environmental measurement spectra.

START

RESULTS

Activity concentrations for ^{122}Xe were calculated using counts from its progeny, ^{122}I . Observations of ^{125}I were also observed.

CONCLUSION

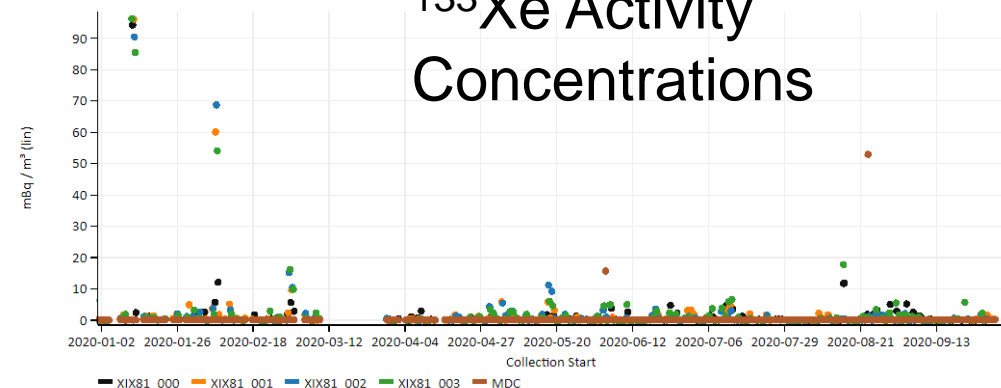
The observations of these xenon isotopes indicate these isotopes are a background that could be present in the world especially near research reactors/accelerators.

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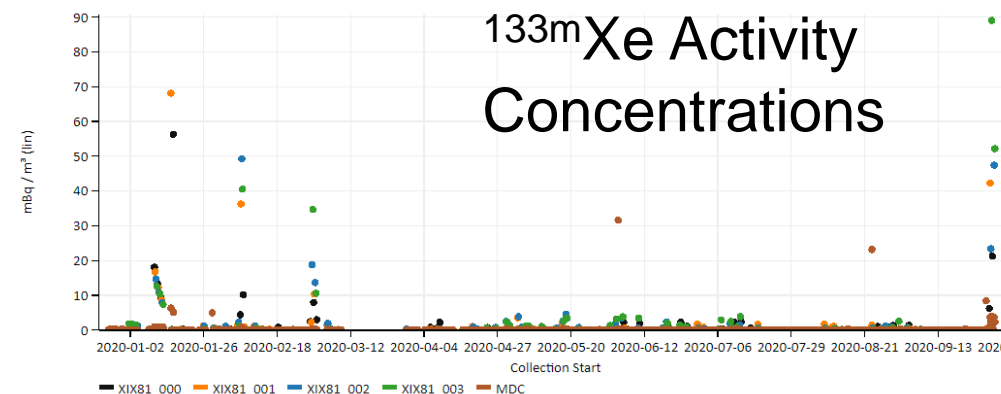
- Traditional backgrounds of atmospheric xenon samplers
 - Medical isotope production facilities
 - Nuclear reactors
 - No others observed until now
- Xenon International observed nontraditional xenon isotopes
 - Next generation radioxenon system
 - Better sensitivities and larger Xe volume than current systems
 - Was undergoing system testing in Knoxville, TN



^{133}Xe Activity Concentrations



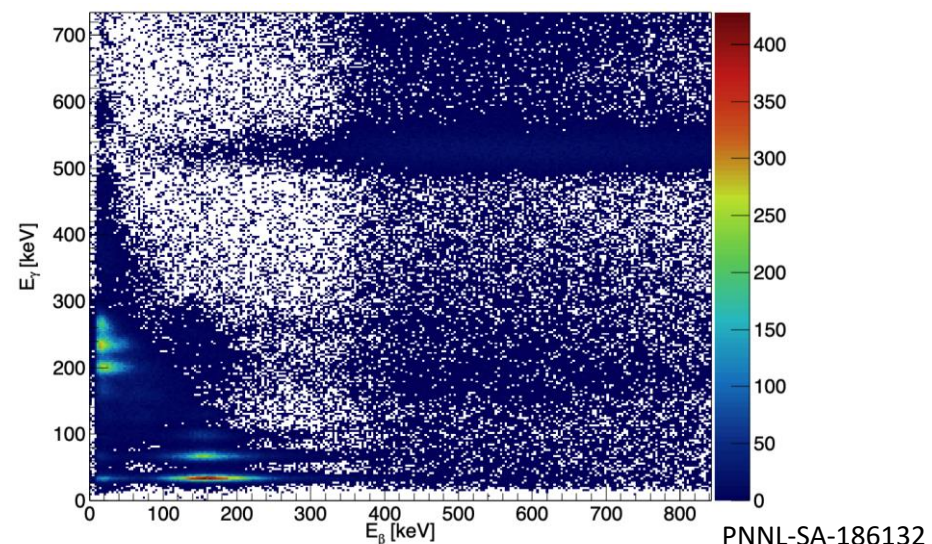
^{133m}Xe Activity Concentrations



During testing in Knoxville, TN, ratios between ^{133m}Xe , ^{133}Xe , and ^{131m}Xe seemed to indicate there were issues with the samples.

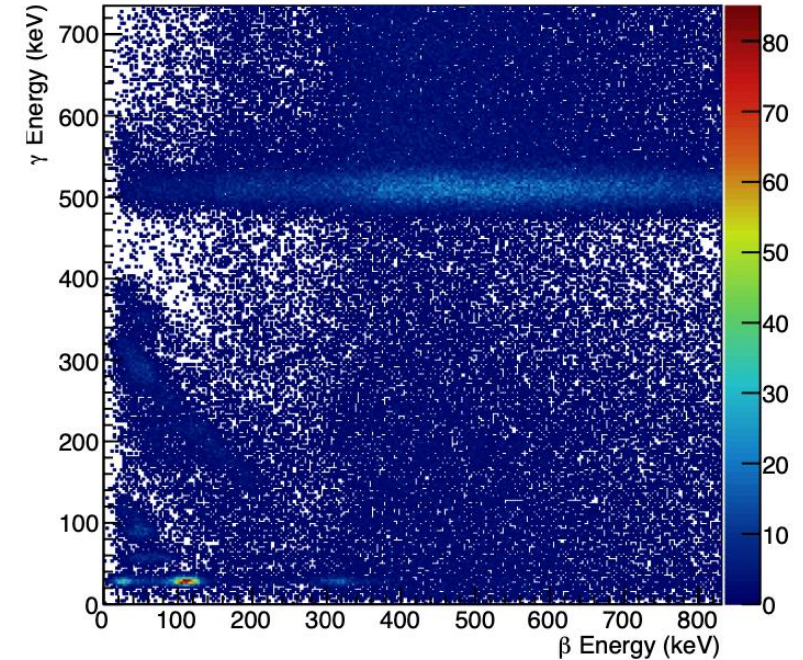
Coincidence and singles spectra did not correspond to the conventional fission xenon isotopes of ^{135}Xe , ^{133}Xe , ^{131m}Xe , and ^{133m}Xe .

Isotopes of xenon were observed to be ^{125}Xe , ^{127}Xe , and ^{129m}Xe , and ^{122}Xe . Iodine isotopes of ^{125}I and ^{122}I were also observed as daughter products of ^{125}Xe and ^{122}Xe , respectively.



- Monte Carlo simulations performed to observe clean signatures and extract efficiencies
- ^{122}Xe daughter ^{122}I ($T_{1/2}=3.63$ minutes) produces signature around 500 keV
- Likely possible source of production of ^{122}Xe is via spallation in the mercury target at Spallation Neutron Source (SNS)
- Concentration equation formulated based on observation of ^{122}I counts

^{122}Xe Full Decay Chain Simulation



$$Conc_{^{122}\text{Xe}}\left(\frac{m\text{Bq}}{m^3}\right) = \frac{\Delta C_{^{122}\text{I}}}{\frac{\lambda_{^{122}\text{I}}}{\lambda_{^{122}\text{I}} - \lambda_{^{122}\text{Xe}}} \left[\left(\frac{1}{\lambda_{^{122}\text{I}}} e^{-\lambda_{^{122}\text{I}} T_A} - \frac{1}{\lambda_{^{122}\text{Xe}}} e^{-\lambda_{^{122}\text{Xe}} T_A} \right) + \left(\frac{1}{\lambda_{^{122}\text{Xe}}} - \frac{1}{\lambda_{^{122}\text{I}}} \right) \right]} * \frac{1}{\varepsilon_\gamma \varepsilon_\beta BR_\gamma BR_\beta +}$$

$$* \left(\frac{\lambda_{^{122}\text{Xe}} T_C}{1 - e^{-\lambda_{^{122}\text{Xe}} T_C}} \right) \left(\frac{1}{e^{-\lambda_{^{122}\text{Xe}} T_P}} \right) \left(\frac{1000}{V_{\text{Air}}} \right)$$



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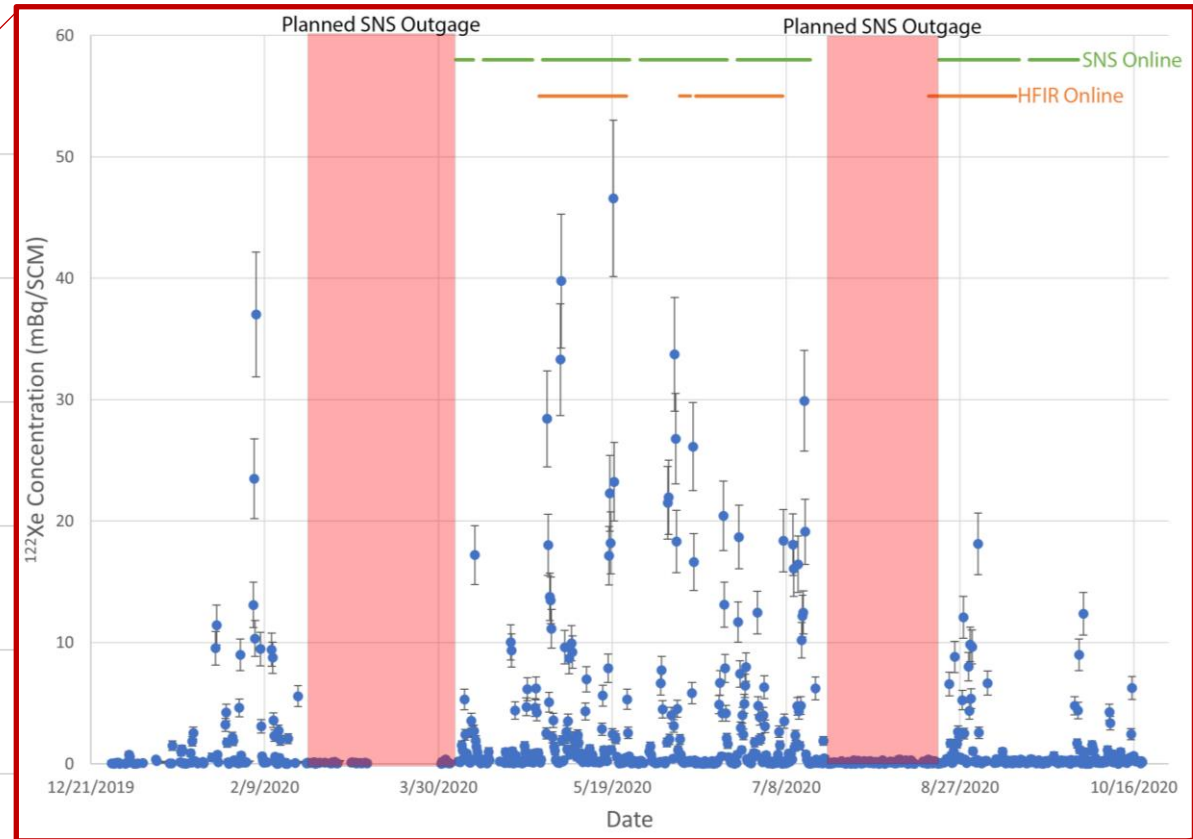
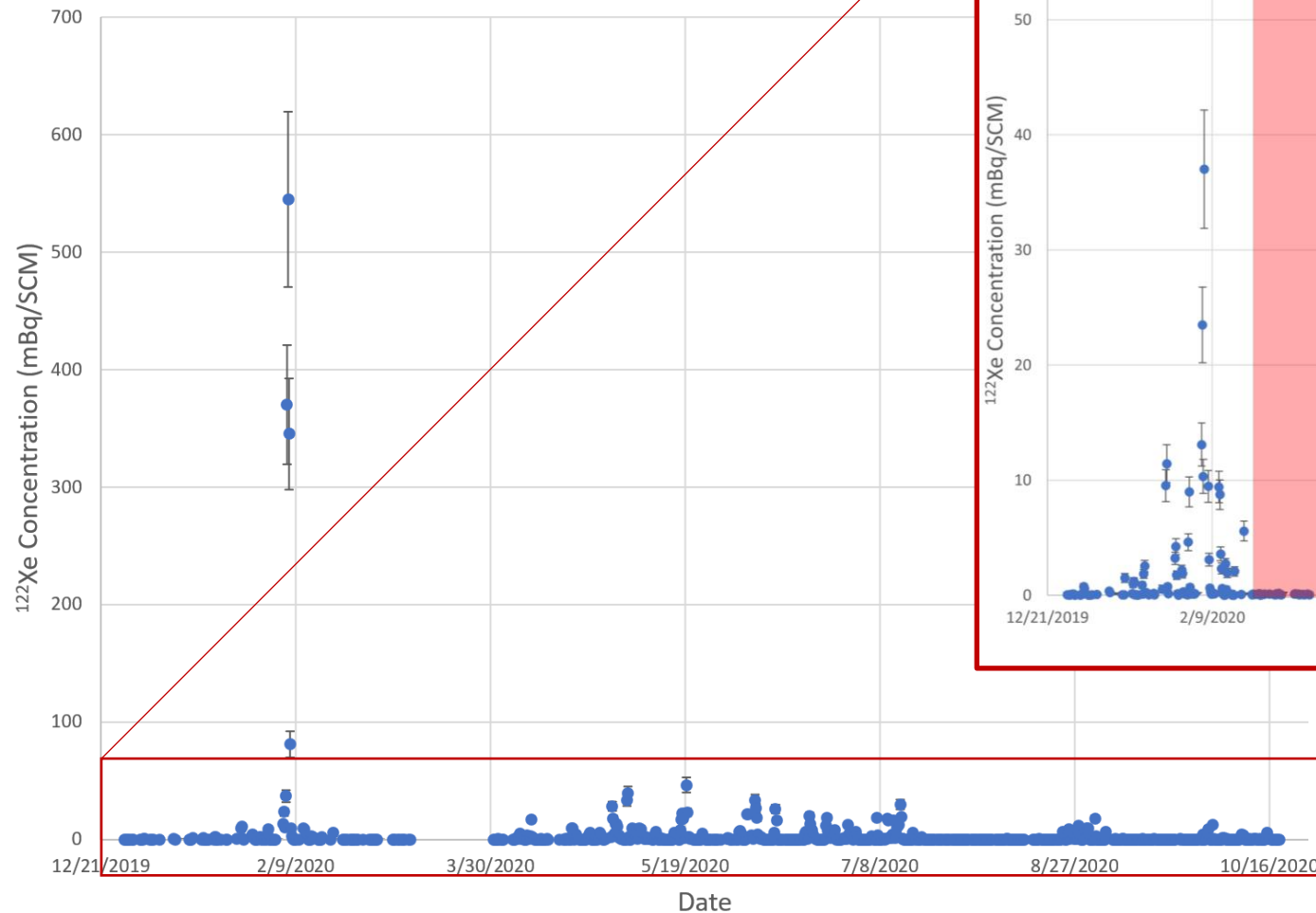
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^{122}Xe Activity Concentration over the Sampling Period



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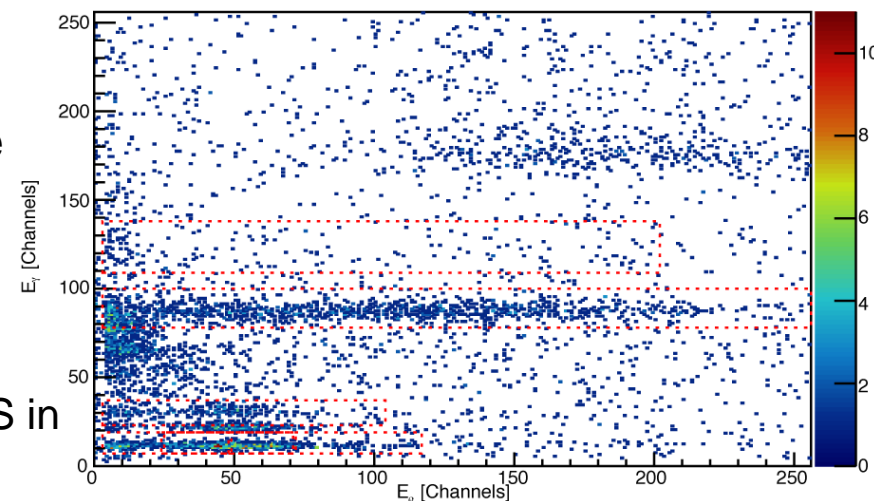
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- Newly observed isotopes seen near High Flux Isotope Reactor and SNS suggest new source of interfering xenon background (scientific research facilities)
 - Neutron irradiation and spallation facilities can produce and release xenon
 - Several spallation sources online or coming online:
 - ISIS neutron source in the United Kingdom
 - Japan Proton Accelerator Research Complex (J-PARC)
 - Los Alamos Neutron Science Center (LANSCE) and SNS in the United States of America
 - European Spallation Source in Sweden
 - China Spallation Neutron Source
- New isotopes interfere with all traditional ROIs used for activity calculations
 - Algorithms will continue to calculate normally
 - Concentrations and ratios will not make sense
 - ^{125}I might cause issues with ^{133}Xe activity concentration due to its long half-life if there is a large concentration in the detector



Multiple isotope xenon collection with ^{135}Xe , ^{122}Xe (^{122}I), and ^{125}Xe

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Brander, S. *et al.* Phase II testing of Xenon International on Mount Schauinsland, Germany. *J Environ Radioact* **255**, 107034 (2022).

Eslinger, P. W. *et al.* Determining the source of unusual xenon isotopes in samples. *J Environ Radioact* **247**, 106853 (2022).



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